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ABSTRACT

Organizations have invested in knowledge management initiatives to introduce and promote collaboration between employees. The goal of this research is to discover how best to transfer knowledge in the form of narratives between project managers to prevent the repetition of past mistakes. First, theories from education and psychology are critically examined to determine how to support the transfer of knowledge within the project management domain. A research study is then conducted to determine if the hypotheses posed through the examination of theory are applicable to the current context. Using the theoretical foundation, a conceptual model, PACE, is developed as a method of applying the knowledge gained from this research to current practice.

Keywords

software project management, design research, knowledge transfer, PACE

INTRODUCTION

The Standish Group, a research advisory firm, reports that only one-third of the over 13,500 information technology projects evaluated in the 2003 CHAOS report were successful, and half of the information technology projects in this report are classified as challenged, meaning these projects experienced cost and budget overruns. Translating the percentages into dollars, in the United States alone, $140 billion was wasted on failed and challenged projects, which is over half of the $250 billion spent on all information technology projects in 2002.

Planning, decision-making, and problem-solving are knowledge intensive activities that are components of project management, which is typically comprised of complicated and ill-structured problems (Grupe, Urwiler, Ramarapu, and Owrang 1998). Valuable knowledge gained before, during, and after projects is rarely captured and utilized. Reinvention of solutions, repetition of mistakes, and loss of process knowledge after project completion are knowledge-related problems that frequently occur during projects. These problems transpire due to turnover of project managers, failure to capture and reuse knowledge throughout and after the project, and insufficient technology to integrate knowledge with extant project management software (Tiwana and Ramesh 2001). The complexity of managing software projects and the loss of knowledge that occurs during the process emphasize the criticality of finding a method to properly reuse knowledge obtained during previous projects.

Using design research principles (Vaishnavi and Kuechler 2004), this research focuses on *how* best to share knowledge in the form of narratives between project managers in an effort to avoid the mistakes that other project managers have made. This research employs a unique approach to achieve that goal. Theories from diverse fields such as psychology and education are critically examined and hypotheses are proposed to determine how to support the transfer of narrative knowledge within the project management domain. A research study is conducted to examine the hypotheses. A conceptual model is developed as a method of applying the knowledge gained into practice.

EXAMINATION OF RELATED THEORY

In an effort to determine *how* knowledge can be shared and transferred among project managers, several theories are examined. Because project management is a learning process involving decision-making and problem solving, situated learning is an applicable theory from education. In addition, social cognitive theory and the concept of feedforward from psychology offer further insight regarding methods to best transfer knowledge between project managers.

Social Cognitive Theory: Self-Efficacy

Social cognitive theory is a model of individual behavior in which social pressure and personal characteristics influence both a person's behavior and environment. One component of this theory is self-efficacy, which is defined as "the beliefs in one's capabilities to organize and execute the course of action required to produce given attainment" (Bandura 1977). Bandura (1977, 1986) states that self-efficacy is not what skills a person possesses, but rather the judgment a person has regarding the ability to perform with the skills one holds.

Wood and Bandura (1989) found that individuals with higher self-efficacy tend to have higher performance than those individuals with lower self-efficacy in terms of willingness to accept and persevere in a challenging task. Considering the challenging nature of project management, self-efficacy should be an important trait for project managers. Self-efficacy is based on four types of information: mastery experience, vicarious experience, verbal persuasion, and physiological and affective states (Bandura 1997). Vicarious experience is obtained by observing others' similar behaviors. Applying this concept to project managers within a community, project managers could learn vicariously through other managers through the use of oral or written narratives. Furthermore, vicarious learning strengthens project managers' self-efficacy, which leads to better expectations regarding the outcome. Therefore, the following hypotheses should be examined.

H1a: Subjects will have higher self-efficacy after reading narratives than before reading narratives.

H1b: Subjects will have more confidence in the outcome after reading narratives than before reading narratives.

Through self-reflection of past experiences, a story is the process by which one attempts to explain and understand an experience. Stories, or narratives, are a natural method for one to both recount experience gained during an activity and to share the information with others (Robinson and Hawpe 1986). Orr (1990) observed a community of photocopier repair technicians who commonly told narratives regarding service diagnoses and encounters. Because the technicians shared experiences, the community knowledge was increased. For a project manager with limited experience and self-efficacy, he/she is able to analyze the decision-making process used by experts to solve a current problem through the use of narratives (Colaric, Turgeon, and Jonassen 2002). Therefore, novices should be able to vicariously learn from experts through the use of narratives or stories of past experiences. This suggests the following hypotheses:

H2a: Subjects without project management experience (novices), after reading narratives, will have self-efficacy consistent with subjects that have project management experience (experts).

H2b: Subjects without project management experience (novices), after reading narratives, will have confidence levels consistent with subjects that have project management experience (experts).

Situated Learning Theory: Learning in Context

Situated learning theory states that learning is naturally associated with activity and context. Classroom learning, which is abstracted and taken out of context, is contrasted with situated learning, or knowledge in an authentic context. Learning is a social process in which one should collaborate and interact with others to gain knowledge, and one common method of implementing situated learning includes communities of practice. These communities involve a novice and an expert, in which the novice assumes specific roles and responsibilities with little interaction between the novice and the expert (Lave and Wenger 1990).

Once a project is completed, the actions and events should be recorded and added to the knowledge repository in an effort to retain lessons learned. In the field of project management, novice project managers make many mistakes as they learn the best practices of both project management and domain-specific issues; meanwhile, more experienced project managers have learned valuable lessons and gained knowledge through trial and error. The organic nature of the repository accumulates "wisdom" over time and becomes more valuable. By recounting experiences through the use of narratives, project managers can share and exchange their knowledge with others. Furthermore, by storing narratives in a collective database, geographical and temporal barriers that impede traditional face-to-face learning are overcome by forming a virtual community of practice. Members receive support from others in the form of both narratives and collaboration. It has been found that the reuse of similar knowledge significantly improves productivity in project management (Henninger 1995). Therefore, the use of situated learning advocates the following hypothesis:

H3: Subjects will use the best practices from expert managers expressed in narratives when performing the project management task.

Feedforward: Enabling a Comprehensive Perspective

Hograth (1981) asserts that feedback derived from outcome, or outcome feedback, increases individual's understanding of problems and decision-making quality. However, outcome feedback occurs only after the result, which is too late for projects with high stakes. In contrast to feedback, an effective alternative is known as "feedforward." By providing information about the task (Bjorkman 1972) and/or the heuristics for performing the task effectively (Malloy, Mitchell, and Gordon 1987), individuals achieve better decision-making quality and thus better performance. Bjorkman (1972) indicates that feedforward avoids the possible bias derived from outcome feedback, given the high accuracy and consistency of knowledge supplied in advance. Feedforward reduces the cognitive loading on individuals, such as project managers.

Empirical studies support the effectiveness of feedforward on the quality of decision-making (Malloy et al. 1987, Sengupta and Abdel-Hamid 1993). In an experiment by Sengupta and Abdel-Hamid (1993), the group with feedforward was provided with in-depth knowledge about the effect of hiring on the productivity of the project workforce on software engineering. This group outperformed the group without feedforward. With feedforward, individuals are equipped with better knowledge for evaluation of the situation.

The key challenge to exert the power of feedforward is to convey knowledge at the right time during the decision-making process (Sengupta and Abdel-Hamid, 1993). This can be achieved by proactively monitoring the individual's course of action. This concept could be applied to project management activities by presenting project managers with knowledge at critical points during their decision-making process. This examination of feedforward suggests the following hypothesis.

H4: Subjects will become aware of potential problems not previously considered in their initial solution, and express these potential problems in the revised solution, after reading narratives.

RESEARCH STUDY

Methodology

To test the hypotheses, a free simulation experiment was developed (Fromkin and Streufert 1976) in which the subjects were able to make decisions regarding the treatment. In this method, subjects are exposed to a treatment, but are free to choose the range of the treatment, much like they would do in a real setting (Gefen and Straub 2000). A project management scenario from Gido and Clements (1998), which describes a project in progress that was behind schedule, along with an outline of problems the project was facing, was used in the experiment. After reading the scenario, in the pre-test phase of the experiment, subjects were asked to explain in detail how they would get the project back on schedule, and the impact that these changes would make on the project in terms of quality, time, and cost. For a quantitative assessment, subjects were asked to rate on a seven-point scale their confidence in their solution in terms of schedule, quality, and cost. In addition, six items were adapted from a prior study (Compeau and Higgings 1995, Hoeltje, Zubrick, Silburn, and Garton 1996) to measure subjects' project management self-efficacy. The next phase of the task asked subjects to read one-page narratives regarding various topics related to project management. All narratives were taken from the Project Management Institutes' handbook (Pinto 1998). Because the experiment was designed as a free-simulation, subjects were told to read as many or as few narratives as they deemed necessary to solve the problem and rate the applicability of the narrative to the scenario. In the post-test, subjects were asked again to specify what actions they would take to resolve the scenario, and the impact that this change would have on the project. Subjects' self-efficacy and confidence was measured again, but in the context of using narratives for assistance in solving the project management problem.

A pilot test was administered to two project managers currently working in industry (experts) and two students with no project management experience, with the exception of a project management course taken the previous semester (novices). Based on the results of the pilot test, it was determined that the scenario was realistic, and minor modifications were made to the instrument to ensure clarity. In addition, the pilot test subjects ranked the narratives based on their applicability to the scenario. This ranking was used to order the narratives for the next phase of the study.

Undergraduate and masters students, enrolled in project management courses at a large US university, were invited to participate in this research study. The instrument was distributed to the subject list via an email attachment. 16 subjects participated in the study. Participation in this study was voluntary, and the instructors offered no incentives. The incentives offered by the researchers included a $10 token of appreciation and sharing of a summary of the research results. Most participants both before and after the study's completion stated a strong interest in the study and its results, which suggests that subjects were willing to put forth a good effort in performing the task.

Results

The multiple item measures for subjects' self-efficacy were quite reliable. Cronbach's alpha was 0.95 and 0.97 for subjects' original self-efficacy and narrative self-efficacy, respectively. Summated scales were then created to test the within-subject difference before and after reading the narratives. A one-tailed paired-samples t-test[1] showed significant differences between two self-efficacy measures (means 5.05 and 5.56, p=0.01). Subjects had higher self-efficacy with assistance of narratives. *Therefore, Hypothesis 1a was supported.*

Again using one-tailed paired-sample t-tests, subjects' confidence regarding the final outcome of the situation also improved significantly after reading the narratives in terms of meeting the schedule constraint (means 5.31 and 5.75, p=0.05) and maintaining quality (means 5.25 and 5.81, p=0.02). Subjects' confidence regarding keeping costs under control for the project, however, was not significantly different between the original and revised solutions (means 4.44 and 4.56, p=0.37). This is understandable given the emphasis on quality and schedule stated in the scenario and the necessary trade-off between schedule, quality, and cost. Overall, subjects became more confident regarding the solution presented after reading the narratives compared to solution offered before reading the narratives. *Thus Hypothesis 1b was also supported.*

Half (8) of the subjects that participated in this study had no project management experience, and the other half (8) had project management experience ranging from two to eight years. At the start of the study, those without project management experience had an average self-efficacy score of 4.67. After reading the narratives, these same subjects had a mean self-efficacy score of 5.62. A one-tailed paired-sample t-test showed that the mean self-efficacy score rose significantly (p=0.05). However, the subjects that possess project management experience did not have a significant increase in self-efficacy (means 5.43 and 5.60, p=0.15). The self-efficacy scores after reading the narratives are remarkably similar across groups. This suggests that novices have much to gain by reading narratives; these subjects that have only had classroom exposure to project management achieved self-efficacy levels comparable to those that have experience. *Therefore, Hypothesis 2a was supported.*

Subjects were asked about the confidence they had regarding their solution in terms of time, quality, and cost. Before reading any narratives, those without project management experience, had mean confidence levels of 5.25 for time, 5.25 for quality, and 5.00 for cost. After reading the narratives, these subjects had mean confidence levels of 5.75 for time, 5.75 for quality, and 5.63 for cost. A one-tailed paired-sample t-test showed that the confidence levels rose significantly for time (p=0.05) and quality (p=0.05), but not for cost (p=0.20). This finding is similar to the results found in the tests for Hypothesis 1a, which was not surprising. Subjects that possess project management experience did not have a significant increase in confidence for time (means 5.38 and 5.75, p=0.20) or quality (means 5.25 and 5.88, p=0.09). However, these experienced managers had lower confidence in achieving the cost goals of the project after reading the narratives (means 3.88 and 3.50, p=0.04). Therefore, those subjects with experience in project management had similar confidence levels both before and after reading the narratives for the time and quality dimensions, their confidence in achieving the cost objective of the project was lessened. This could imply that for experts, the narratives may have reminded them of the reality of the trade-offs between time, cost, and quality. This result is interesting in that the confidence levels of the subjects across experience groups are similar after reading the narratives for the dimensions of time and quality. However, for cost, there is a large difference between those without experience and those with experience. This suggests that some of the lessons learned by experienced project managers, such as the time/cost trade-off may be more difficult to transfer to novices. This mixed result was surprising and further examination is warranted to determine if this is an artifact of the experiment, the cost dimension, or something else. Threrefore, *Hypothesis 2b was partially supported.*

The final two hypotheses were analyzed using the qualitative data provided by the subjects. Hypotheses 3 and 4 are related to the manner in which the subject solves the project management problem. Because project managers approach problems differently, it was most appropriate to ask the subjects to write their responses and justify them. Therefore the generation and analysis of qualitative data provided a means to reveal some of the complexities that project managers face when solving a problem on a project (Miles and Huberman 1994).

Two coders independently coded the qualitative data for the subjects and then compared the results. Any discrepancy was further discussed and resolved. The final inter-rater reliability was 0.86 and acceptable (Miles and Huberman 1994). Qualitative analysis showed that subjects gained additional knowledge by reading the narratives. They incorporated new elements learned from the narratives and reformulated their original solutions. Ten of the subjects (62.5%) modified their

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[1] All quantitative tests were also analyzed using a non-parametric Wilcoxon paired-sample test, which is a test often used for small samples and has no assumptions regarding normality. The results obtained using non-parametric tests were comparable to the results of the one-tailed paired sample t-test.

responses based on the principles offered in the narratives. The large majority of subjects with no project management experience (87.5%) were able to leverage the principles in their solution. *Hypothesis 3 was thus supported*.

The narratives helped subjects think from perspectives different from those originally considered and to recognize other issues not originally considered. For example, many subjects did not first suggest motivating team members under such pressure, but included comments about morale and incentives in their revised solutions. Also, some subjects did not think very deeply about the original solution and neglected to consider potential drawbacks; however, in the revised solution, it was clear that additional insight was gained by reading the narratives. Subjects usually suggested adding additional team members to accelerate the process, but tended to neglect the required quality of these personnel as well as the risk that additional personnel could delay the project. One subject wrote,

"Reading the narratives gave me some other ideas for motivation and reminded me of some pitfalls associated with allocating additional resources ...."

Other subjects concurred by stating that reading the narratives "*influenced my decision or rationale.*" Based on this analysis, *Hypothesis 4 was supported*.

Table 1 provides a summary of the research results.

Hypotheses	Analysis	Result
H1a: Subjects will have higher self-efficacy after reading narratives than before reading narratives.	Paired t-test	Supported
H1b: Subjects will have more confidence in the outcome after reading narratives than before reading narratives.	Paired t-test	Supported (quality and time)
H2a: Subjects without any project management experience, after reading narratives, will have self-efficacy consistent with subjects with project management experience.	Paired t-test	Supported
H2b: Subjects without any project management experience, after reading narratives, will have confidence levels consistent with subjects with project management experience.	Paired t-test	Partially Supported (quality and time only)
H3: Subjects will use the best practices from expert managers expressed in narratives when performing the project management task.	Qualitative	Supported
H4: Subjects will be aware of potential problems not previously considered in their initial solution, and express these potential problems in the revised solution, after reading narratives.	Qualitative	Supported

Table 1. Results of Research Study

Methodology Discussion

Because this research used a free simulation experimental task (Fromkin and Streufert 1976), the results of the study are more similar to what is experienced in practice. For a "real" project manager making a decision regarding how to handle a situation, he/she would have to decide how much time is available to decide on a course of action. There would be no dictated rules in which the project manager would be required to read a specific number of narratives. The project manager would read only the narratives that he/she thought would be applicable to the situation and only as long as they proved helpful. This phenomenon fully corresponds with the experiment. Some subjects read as few as one narrative, while others read all eight narratives provided, which is similar to what different project managers would do when faced with a similar situation. Additionally, project managers are often pressed for time, which limits their willingness to seek out information. Because the subjects completed this experiment on their own time, rather than in a classroom or during a preset amount of time, the subjects had their own time constraints as well. There was a small token granted to each participant for their time, but this was in no way a method to reimburse them for the time spent. The subject had to decide how much time he/she was willing to invest in reading and applying the narratives while he/she was balancing work, school, and social responsibilities, much like a project manager who is tasked with many objectives at once.

In an effort to further explore the theories examined within the context of project management, a series of interviews is being conducted to determine how knowledge is reused for a specific problem on software projects, managing user expectations. This exploratory work is aiding in the understanding of how software project managers currently transfer knowledge for the given problem of managing user expectations. Although this research is not completed, both expert and novice project managers had experiences that directly support the theories and hypotheses presented in this research. Although the study described in this paper was comprised of a small sample and used students of mixed experience, research currently underway suggests that the findings of this study are indeed applicable to practitioners.

APPLICATION OF THE FINDINGS

Because the goal of this research focuses on how to support project managers in their transfer of knowledge, design research principles are used to apply the findings of the research study to practice. Given that the theories were generally found to endure within the context of project management, a conceptual model was developed based on the findings. The model proposed is one of several methods that could be used to operationalize the hypotheses as part of project management practice. This multimethodological approach aims to progress this research to the next step by creating an artifact (Nunamaker, Chen, and Purdin 1991) to improve the transfer of knowledge within the project management community.

PACE (Problem Avoidance with Cases and Expertise) is a conceptual model based on the theories to transfer knowledge between project managers. Many organizations employ both project management systems and knowledge management systems, but these organizations do not receive the benefits that a system based on PACE can provide. PACE is unique because of the integration of the knowledge management and project management systems.

Hypotheses 2a and *2b* examined the importance of using knowledge in the form of narratives as a surrogate for experience. This is operationalized in PACE via a database called the *Narrative Library*. The narratives in this library consist of experiences from projects managers and publicized literature of best practices, success stories, and project failures. Because PACE enables project managers to learn from their peers and other sources, vicarious learning occurs, which is relevant to the findings of *Hypotheses 1a* and *1b*.
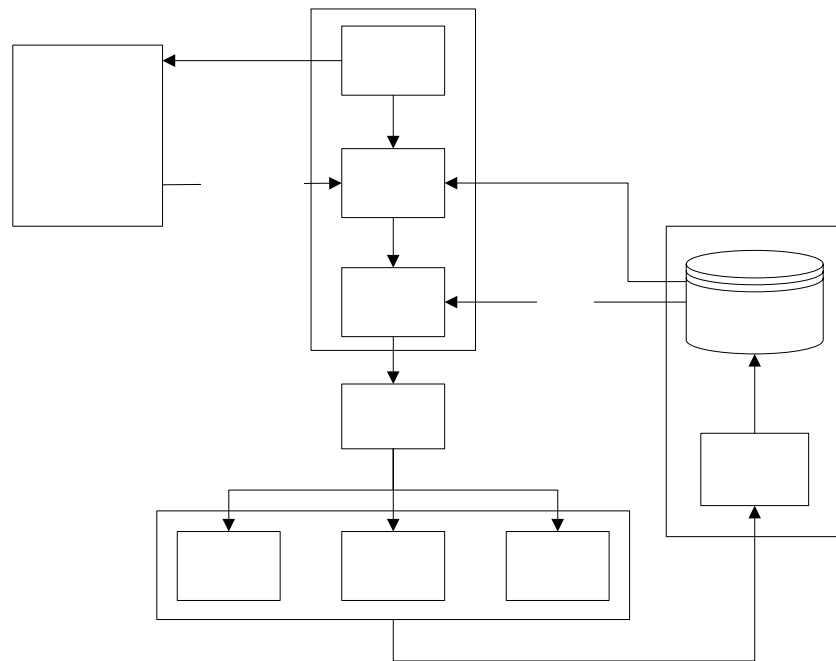

Figure 1. PACE

Feedforward, *Hypothesis 4*, is implemented through the *Monitor* and *Trigger* components, which is an integration point between the knowledge management and project management systems. PACE is distinctive from other systems in that the knowledge management system becomes a component of the project management system via the monitor and trigger mechanisms. During a project, the project manager makes updates to the plan via the project management system. With PACE, an alert appears if narratives are associated with the modification to the plan. Rather than requiring the project

Integration

manager to realize there is a problem, and then access an independent knowledge management system, PACE alerts the project manager before he/she is aware of a potential problem.

Once the project manager is forewarned of a problem, narratives are retrieved using the *Retrieve* component and presented to the project manager for evaluation. This retrieval of knowledge enables sharing and transferring of knowledge within the project management community. Once narratives are retrieved, the project manager must then evaluate the applicability of the narrative to the current situation. This is accomplished via the *Evaluate* component. If the narratives provided offer similar contexts and situations as the problem encountered by the project manager, then the narrative is applied to the current problem through the *Reuse* component. If the narrative is similar, but varies in context, the project manager adapts narratives and past experiences to the current situation using the *Adapt* component. The ability to reuse past experiences operationalizes *Hypothesis 3*.

If none of the narratives are reusable or adaptable, the project manager must solve the problem using his/her own resources and experiences. When creativity is used to adapt or to create new solutions to problems, the project manager recounts the experience for addition to the *Narrative Library* after the situation has been resolved and an outcome has been reached. After this period of self-reflection, the project manager inputs the new solution using the *Create* component. Validation is a critical maintenance component of PACE. The *Validate* component ensures consistent quality of the narratives and determines what is taught to users (Jonassen and Hernandez-Serrano 2002). If the *Narrative Library* is burdened with stories lacking in quality, users will become frustrated and will disregard the system.

CONCLUSIONS

To accomplish the research goal of supporting project management through the use of a more effective knowledge transfer process, theories from diverse fields were examined to determine if they could be applied to the problem. Next, a research study was performed to examine these theories in a project management context. Using insights from the study and theoretical foundations, a conceptual model was developed as means to transfer the knowledge gained into a system that can be constructed to affect knowledge transfer across project managers.

This research is addressing a design research question in an effort to create an artifact to improve current practice; however, unlike a large number of design research studies, this work integrates theory and explanatory work into the design of an artifact. This unique approach yields a novel and theoretically-based artifact that can contribute to improving project management practice. Through this research, it was clear that project managers want to learn and leverage knowledge from others, but often struggle in the application. Future research will continue to examine how project managers transfer knowledge across and between projects, and will aim to fully design an artifact that can facilitate the transfer of knowledge across project managers in a more efficient and effective manner.

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